

Toward practical handling of metal clusters as functional materials

Hisato Yasumatsu

*Advanced Research and Innovation Center, DENSO CORPORATION
Nisshin, Aichi 470-0111, Japan;
hisato.yasumatsu.j2d@jp.denso.com*

We have discovered that uni-sized Pt clusters can be fixed on an Si substrate as Pt cluster disks through impact of size-selected Pt cluster ions onto the substrate surface:¹ cluster impact.² In this innovative material, electrons accumulate at the sub-nano interface between the Pt cluster disk and the Si surface,^{3,4} enabling catalytic NO reduction^{5,6} and CO oxidation⁷⁻⁹ at low temperatures through effective bond splitting of NO and O₂, respectively, by electron capture in their antibonding molecular orbitals.

Under practical conditions, silicon carbide (SiC), renowned for its chemical and thermal stability, can substitute Si as a substrate.^{5,6} In the present talk, I will provide compelling evidence that the Pt clusters supported on the SiC substrate, prepared in vacuum by the cluster impact onto the SiC surface, maintain their low-temperature catalytic activities in the CO oxidation and the NO reduction under practical conditions as high as 1200 K and atmospheric pressure.¹⁰ The cluster-size dependence and details of the experimental apparatus will also be discussed.

Accumulated electrons hold promise for contributing to key steps of important reactions such as O₂ splitting for the O₂ reduction reaction (ORR) in fuel cells, and H₂O splitting for the H₂ evolution reaction (HER) in artificial photosynthesis. To utilize the supported clusters as functional materials for catalysis and other applications, such as strong permanent magnets,¹¹ mass synthesis and global analysis are essential. The final part of the talk will demonstrate laboratory automation for practical manufacturing.

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